Research Paper | Chemical Engineering | E-ISSN No : 2454-9916 | Volume : 2 | Issue : 12 | Dec 2016

APPLICATION OF NANO PARTICLES FOR DYES DECOLORIZATION USING BIOSYNTHESIS OF TITANIUM OXIDE NANO PARTICLES

Dr. CH. A. I. Raju [1] | R. Mahalakshmi Kalyani [2] | K. Satyanandam [3] | K. Prem [3]

[1] Assistant professor, Dept of Chemical Engineering, A. U. College of Engg., Visakhapatnam, India – 53000.
[2] P.G. Student, Department of Chemical Engineering, A. U. College of Engg., Visakhapatnam, India – 530003.
[3] Research Scholar, Dept of Chemical Engg, A. U. College of Engg., Visakhapatnam, India – 530003.

ABSTRACT

Plenty and pretty applications of nano particles have gained utmost priority now a days due to their versatile flexibility in wide range of applications.. In the present research, experiments were carried out using Titanium dioxide nano particles for dyes decolourization using AntigononLeptopus leaves by Biosynthesis Process. The variables incorporated in the present study are Contact time, pH, initial Concentration of Dyes, Dosage of nano particle solution and temperature. The characterization studies were carried out using XRD and FTIR. The dyes considered for the present study are Solo Chrome Black(SCB), Titan Yellow(TY), Bromo Thymol Blue(BTB), Bromo Cresol Purple(BCP). The Optimum pH for SCB-4, TY-5, BTB-6 and BCP-7. The Positive Results confirmed that antigononLeptopus Leaves broth combined with Titanium dioxide solution formed Titanium Nano Particles and it is capable of removing dyes.

KEYWORDS: FTIR, pH, Dyes, Dosage, XRD, Concentration.

Introduction

The name and fame of nano particles has reached pinnacle due to its versatile and flexibility in applications. The maximum attention has turned towards nano particles for degradation of waste waters due to their high surface area and high stability [01–09]. The metal oxide nano particles produced from biosynthesis have gained much importance and are widely used for decolorization of dyes waste waters due to low cost, ecofriendly nature and non-toxicity [10, 11]. Hence an attempt is made for dyes declorization using titanium nano particles obtained from biosynthesis using antigononleptopus leaves.

Materials and Methods:

The present experimentation is carried out in batch process, forremoval of dyes (Solo Chrome Black–SCB, Titan Yellow–TY, Bromo Thymol Blue–BTB, Bromo Cresol Purple–BCP) from aqueous solutions by using AntigononLeptopus leaves with Titanium nano particles (al-ti-nps)

Fig. 1. Dyes

Analytical grade chemicals were used for experimentation and need no further purification. Double distilled water is used to prepare all stock and synthetic solutions. From a stock solution containing 1000 mg of dyes in 1.0 litre, the synthetic solutions of dyes were made. By addition of O.l M HCl and O.l M NaOH solutions the pH of dyes solutions were adjusted to the desired value.

Preparation of the Broth solutions and Nano particles formation:

Preparation of AntigononLeptopus broth :

In this process 10 gm of fresh and cleaned leaves of AL are taken in a magnetic stirrer and to this 110 ml of distilled water is added and it is heated at 60oC for 10min.After that the solution is filtered in 250 ml conical flask using whatmann's filter paper and it is kept aside for further process. The broth obtained is in pale yellow colour

Fig.2AntigononLeptopus Leaves

Preparation of Nano Particles:

In this process 10 ml of broth solution is taken and to that 90 ml of TiO_2 is added in a 250 ml conical flask and is kept in an orbital shaker for 24 Hrs in order to obtain nano particles. The nano particles formation is noticed when the pale yellow color is changed to White color. This solution is used for various dyes degradation process of different concentrations and different dosages.

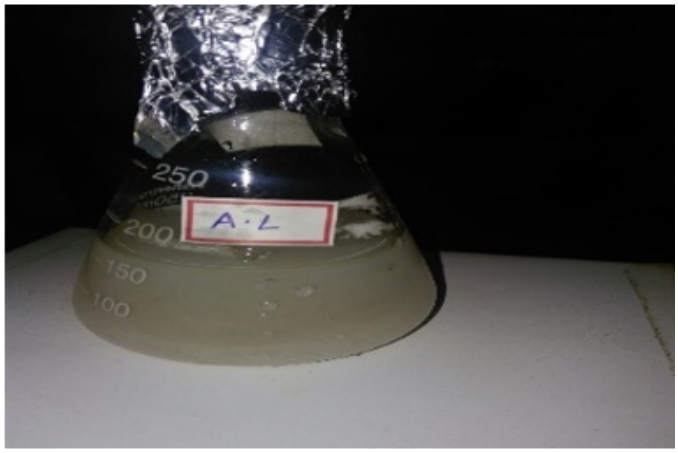

Fig. 3 Nano particles solutions forAntigognonLeptopus

Characterization Studies:
Characteristic studies were carried by XRD and FTIR.

Fig. 4 Centrifuge samples for drying and Characterization analysis (FTIR & XRD)

Results and Discussions:
CHARACTERIZATION.
FTIR Spectrum
The FTIR spectrum of TiO2 nanoparticles is shown in Figure 5 with the broth antigononleptopus. The fundamental mode of vibration for AntigononLeptopus Broth at 3411.26 which correspond to the N-H Bending from Amines, 3293.59 which correspond to the C-H Stretch from alkane, 2851.88 which corresponds to C-H Stretch from alkane. 1634.74 which correspond to N-H bending from amine. 1010.74, 1017.49, 1067.65, 1125.51, 1221.96, 1232.57, 1277.90, 1383.96 which corresponds to C-F Stretch Alkyl Halides. 930.69, 938.41, 976.99 which corresponds to =C-H bending from Alkenes. 602.78, 633.64, 640.39, 649.07, 652.58, 668.36, 673.19, 696.33, 706.94, 734.91, 742.63, 768.67 which corresponds to C–Cl stretch from alkyl halides[12-16].

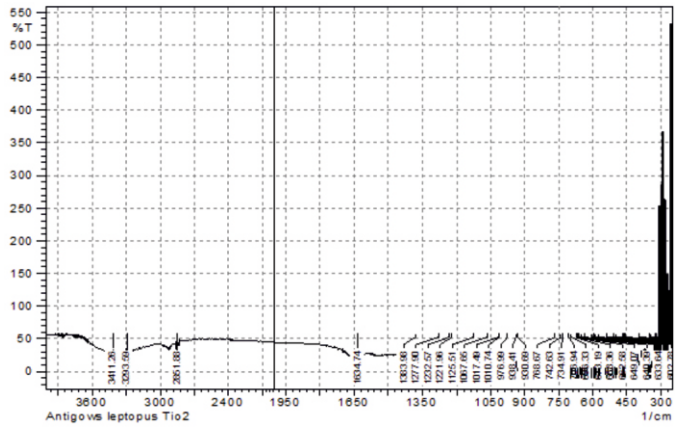

Fig.5FTIR Spectrum of AntigononLeptopus Titanium nano particles

X-Ray Diffraction
Fig. 6 shows the XRD for the Titanium nanoparticles using Antigononleptopus broth. The peaks at 2θ values of0.9641, 0.8866, 0.7709 and 0.5357 corroborate Cd2.06 FCl.44O14P4, KLiO4.S, AuCSand F2O.Ti. Their corresponding d-values are12.0065, 3.9861, 4.2468, and1.700respectively[12,17-20].

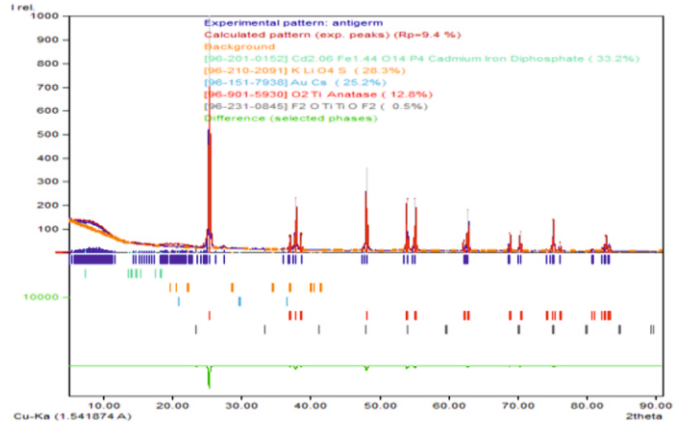

Fig. 6 XRD pattern of AntigononLeptopus Titaniumnano particles.

Effect of contact time
The Decolourization of Dyes(Solo Chrome Black–SCB, Titan Yellow–TY, Bromo Thymol Blue–BTB, Bromo Cresol Purple–BCP)was studied as a function of contact time at Room temperature. 20 ml of 20 mg/L Dye solution was taken with 5 ml of AntigononLeptopus broth Titanium nano particles (al-ti-nps) solution at different time intervals ranging from 1 hr to 72 hrs. At the start, the ions adsorbed and occupied selectively the active sites on the al-ti-npssolution. As the contact time increased the active sites on the al-ti-nps were filled. The rate of adsorption became gradually slower and reached an exhaust stage, resulting constant value. The results obtained are shown in figure 7. As a result of the experiment, the highest % Removed for the Dyes (SCB, TY, BTB, BCP) was 53%, 54%, 48%, 47% at the time of 18 Hrs, 24 Hrs, 16 Hrs, 20 Hrs. [21-25].

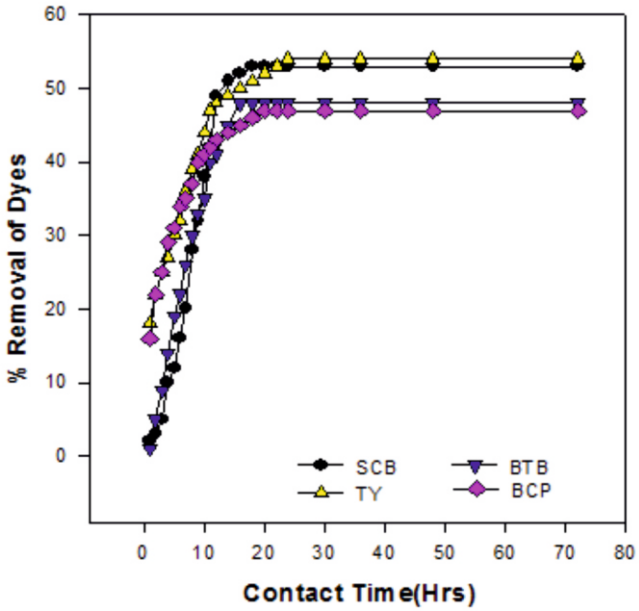

Fig. 7 Effect of Contact time for % Removal for AL

Effect of pH
In order to find the effect of pH on Dye Decolourization using the AntigononLeptopus, experiments have been carried out at various initial pH values and results are given in figure 8.The removal was increased from 22 % to 59 % as pH was increased from 2 to 8,the pH is varied for every dye used with the broth solution AntigononLeptopus whereas further increase in pH had a negative effect. The maximum % removal was found to be 53 % at pH 4 for SCB Dye, 59% at pH 5 for TY dye, 56% at pH 6 for BTB dye, 51% at pH 7 for BCP dye [26-30].

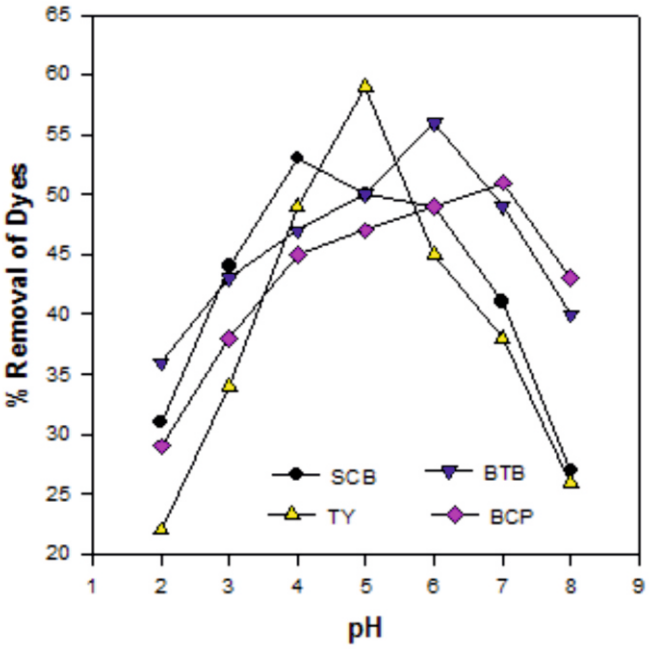

Fig. 8 Effect of pH for AntigononLeptopus leaves

Effect of Concentration:
The percentage Removal of dyes at various initial concentrations is depicted in Fig. 9. At concentration of Dye solution (20 mg/L), maximum %removal is obtained and is different for every Dye using Broth AntigononLeptopus and on

further increase in concentration (200 mg/L), %removal has been decreased. This is due to higher interaction between AntigononLeptopus Broth and the Dye solution. The maximum removal of SCB Dye is 56%, TY dye is 62%, BTB dye is 64%, BCP is 59 %[31-35].

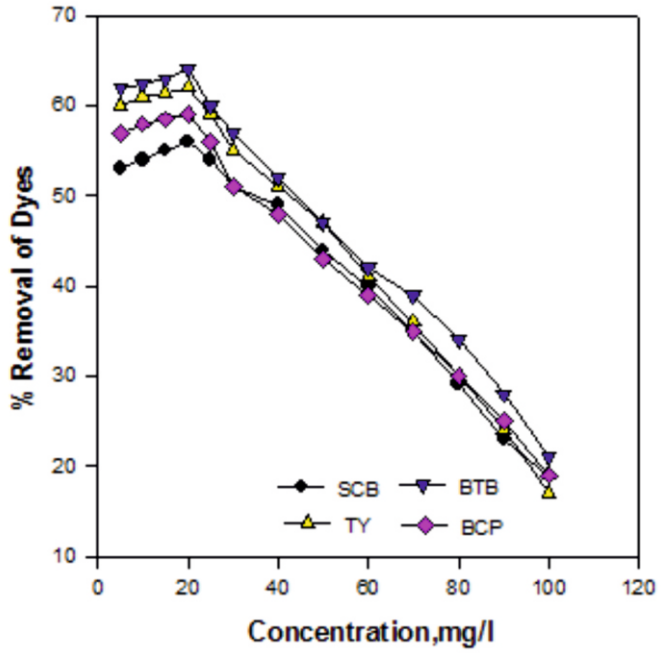

Fig. 9 Effect of Concentration for AntigononLeptopus leaves

Effect of Dosage:

The variation of % removal of Dyes(SCB, TY, BTB, BCP) was studied using different dosages of the broth AntigononLeptopus. Results from the fig 10 showed that % removal of Dyes (SCB, TY, BTB, BCP) increased. The maximum % removal is attained at 11 ml and was almost constant at higher dosages. This trend could be explained asa consequence of partial aggregation.Therefore, the optimum dosage was selected as 11ml for further experiments. The maximum % removal of SCB dye is 76%, TY dye is 86%,BTB dye is 75%, BCP dye is 68%. This trend can be predicated to larger surface area and availability of more sorption site [36-40].

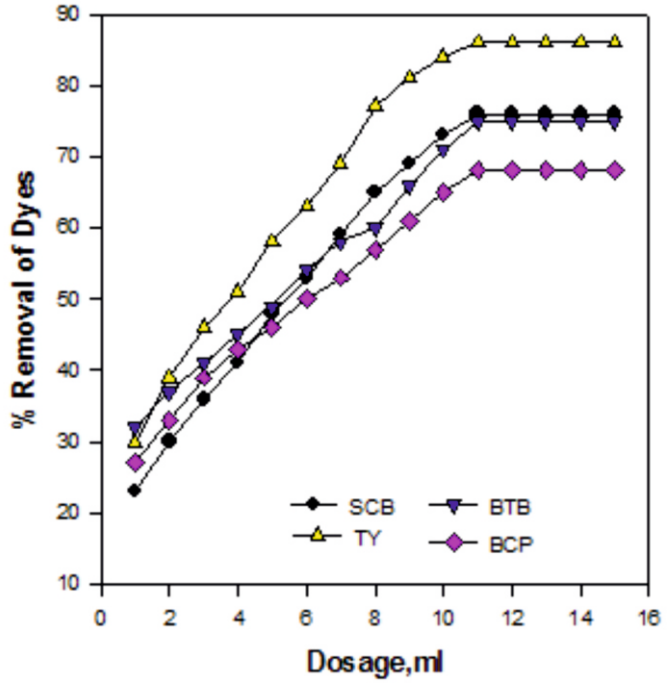

Fig. 10 Effect of Dosage for AntigononLeptopus leaves

Effect of temperature

The dependence of temperature on the % removal of dyes is investigated at different temperatures as given in fig. 11. Results showed that %removal of Dyes (SCB, TY, BTB, BCP) increased from 54% to 89% with increase in temperature from 283 K to 323 K. This indicates that the % removal of Dyes using Broth AntigononLeptopus was controlled by an endothermic process. The increase in removal with temperature may be attributed to either increase in the number of active surface sites available for interaction on the Dyes. The maximum % removal of SCB dye is 83 %, TY dye is 89%, BTB dye is 84 %, BCP is 83 %[41-45].

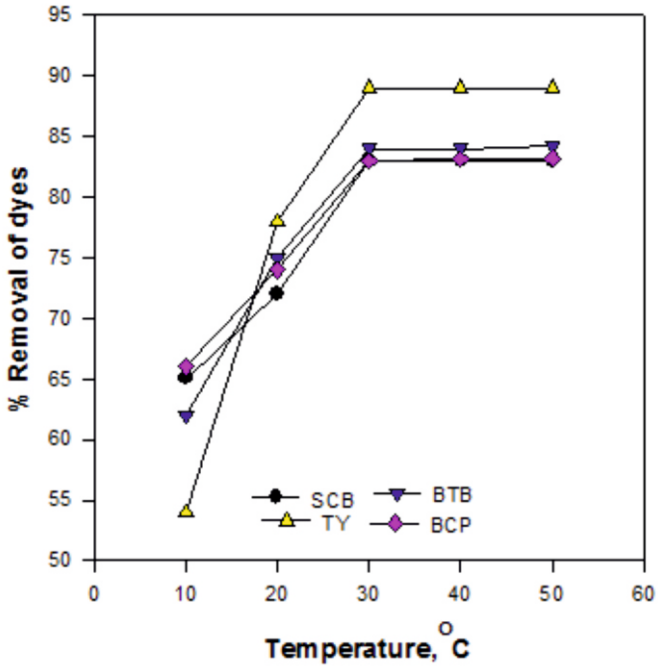

Fig. 11 Effect of Temperature for AntigononLeptopus leaves

Conclusions:

The analysis of the experimental data result in the following conclusions:

1) The maximum dye decolourization of solo chrome black dye onto AntigononLeptopus leaves with TI-nano solution observed when the processing parameters are set as:t= 18 Hrs, pH = 4, w = 11 ml , Co = 20 mg/L and T = 303 K . is 83%.

2) The maximum dye decolourization of Titan yellow dye onto AntigononLeptopus leaves with Ti-nano solution observed when the processing parameters are set as: t=24 Hrs, pH = 5, w = 11 ml, Co = 20 mg/L and T = 303 K is 89%.

3) The maximum dye decolourization of Bromothymol blue dye onto AntigononLeptopus leaves with Ti-nano solution observed when the processing parameters are set as: t= 16 Hrs, pH = 6, w = 11 ml , Co = 20 mg/L and T = 303 K is 84%.

4) The maximum dye decolourization of Bromo cresol purple dye onto AntigononLeptopus leaves with Ti-nano solution observed when the processing parameters are set as: t= 20 Hrs, pH = 7, w = 11 ml, Co = 20 mg/L and T = 303 K is 83%.

With the above conclusions the authors confirm that the above mentioned leaves are capable of removing dyes.

Acknowledgements

The Authors expresses their deep sense of gratitude to Andhra University and Department of Chemical Engineering for providing chemicals, equipment and laboratory facilities. The Authors also expresses their sincere thanks to DST-PURSE programme, Andhra University, Visakhapatnam and Advanced Analytical Laboratory for carrying out characterization (XRD and FTIR).

References

[1] M.Y. Nassar, "Size-controlled synthesis of CoCO3 and Co3O4 nanoparticles by free-surfactant hydrothermal method", Mater. Lett., 94 (2013), pp. 112–11Article PDF (510 K)Citing articles (23)

[2] M.Y. Nassar, A.S. Attia, K.A. Alfallous, M.F. El-Shahat, "Synthesis of two novel dinuclear molybdenum(0) complexes of quinoxaline-2,3-dione: new precursors for preparation of α-MoO3 nanoplates", Inorg. Chim. Acta, 405 (2013), pp. 362–367ArticleView Record in ScopusCiting articles (9)

[3] M.Y. Nassar, T.Y. Mohamed, I.S. AhmedOne-pot solvothermal synthesis of novel cobalt salicylaldimine–urea complexes: a new approach to Co3O4 nanoparticles J. Mol. Struct., 1050 (2013), pp. 81–87

[4] M.Y. Nassar, M.M. Moustafa, M.M. TahaHydrothermal tuning of the morphology and particle size of hydrozincite nanoparticles using different counterions to produce nanosizedZnO as an efficient adsorbent for textile dye removal RSC Adv., 6 (2016), pp. 42180–42195

[5] T. Jiao, Y. Liu, Y. Wu, Q. Zhang, X. Yan, F. Gao, A.J.P. Bauer, J. Liu, T. Zeng, B. Li, "Facile and scalable preparation of graphene oxide-based magnetic hybrids for fast and

highly efficient removal of organic dyes", Sci. Rep., 5 (2015), p. 12451

[6] H. Guo, T. Jiao, Q. Zhang, W. Guo, Q. Peng, X. Yan, "Preparation of graphene oxide-based hydrogels as efficient dye adsorbents for wastewater treatment", Nanoscale Res. Lett., 10 (2015), pp. 1–10

[7] M.Y. Nassar, I.S. Ahmed, "Hydrothermal synthesis of cobalt carbonates using different counter ions: an efficient precursor to nano-sized cobalt oxide (Co3O4)", Polyhedron, 30 (2011), pp. 2431–2437

[8] R. Xing, T. Jiao, Y. Liu, K. Ma, Q. Zou, G. Ma, X. Yan, "Co-assembly of graphene oxide and albumin/photosensitizer Nanohybrids towards enhanced photodynamic therapy", Polymer, 8 (2016), p. 181

[9] R. Xing, K. Liu, T. Jiao, N. Zhang, K. Ma, R. Zhang, Q. Zou, G. Ma, X. Yan, "An injectable self-assembling collagen–gold hybrid hydrogel for combinatorial antitumor photothermal/photodynamic therapy", Adv. Mater., 28 (2016), pp. 3669–3676

[10] Patil R.S, Kokate M.R, Kolekar S.S, SpectrochimicaActa A, 2012, 91, 234–238.

[11] A.-N.M. Salem, M.A. Ahmed, M.F. El-Shahat, "Selective adsorption of amaranth dye on Fe3O4/MgO nanoparticles", J. Mol. Liq., 219 (2016), pp. 780–788.

[12] M.E. Olya , M. Vafaee, M. Jahangiri "Modeling of acid dye decolorization by TiO2–Ag2O nano-photocatalytic process using response surface methodology", Journal of Saudi Chemical Society (2015).

[13] Vinodgopal, K., Darrel E. Wynkoop, and Prashant V. Kamat. "Environmental photochemistry on semiconductor surfaces: photosensitized degradation of a textile azo dye, acid orange 7, on TiO2 particles using visible light."Environmental Science & Technology 30.5 (1996): 1660-1666.

[14] Nasr, Chouhaid, et al. "Environmental photochemistry on semiconductor surfaces. Visible light induced degradation of a textile diazo dye, naphthol blue black, on TiO2 nanoparticles." The Journal of Physical Chemistry 100.20 (1996): 8436-8442.

[15] Zhang, Shunli, et al. "Morphological structure and physicochemical properties of nanotube TiO2." Chinese Science Bulletin 45.16 (2000): 1533-1536.

[16] Moreira, Regina de Fátima Peralta Muniz, et al. "Mass transfer and photocatalytic degradation of leather dye using TiO2/UV." Journal of applied electrochemistry 35.7-8 (2005): 821-829.

[17] Liu, Shengwei, Jiaguo Yu, and MietekJaroniec. "Tunable photocatalytic selectivity of hollow TiO2 microspheres composed of anatasepolyhedra with exposed {001} facets." Journal of the American Chemical Society 132.34 (2010): 11914-11916.

[18] Zhou, Weijia, et al. "Ag2O/TiO2 nanobeltsheterostructure with enhanced ultraviolet and visible photocatalytic activity." ACS applied materials & interfaces 2.8 (2010): 2385-2392.

[19] Kar, Archana, York R. Smith, and Vaidyanathan Subramanian. "Improved photocatalytic degradation of textile dye using titanium dioxide nanotubes formed over titanium wires." Environmental science & technology 43.9 (2009): 3260-3265.

[20] Jiang, Xin, and Ting Wang. "Influence of preparation method on morphology and photocatalysis activity of nanostructured TiO2." Environmental science & technology 41.12 (2007): 4441-4446.

[21] Poursaberi, Tahereh, and MostafaHassanisadi. "Magnetic Removal of Reactive Black 5 from Wastewater Using Ionic Liquid Grafted-Magnetic Nanoparticles." CLEAN–Soil, Air, Water 41.12 (2013): 1208-1215.

[22] Venkatesha, T. G., Y. ArthobaNayaka, and B. K. Chethana. "Adsorption of Ponceau S from aqueous solution by MgO nanoparticles." Applied Surface Science 276 (2013): 620-627.

[23] Kannusamy, Pandiselvi, and ThambiduraiSivalingam. "Synthesis of porous chitosan–polyaniline/ZnO hybrid composite and application for removal of reactive orange 16 dye." Colloids and Surfaces B: Biointerfaces 108 (2013): 229-238.

[24] Xu, Piao, et al. "Synthesis of iron oxide nanoparticles and their application in Phanerochaetechrysosporium immobilization for Pb (II) removal." Colloids and Surfaces A: Physicochemical and Engineering Aspects 419 (2013): 147-155.

[25] Rahmani, A. R., et al. "Degradation of Azo Dye Reactive Black 5 and acid orange 7 by Fenton-like mechanism." Iranian Journal of Chemical Engineering 7.1 (2010): 87-94.

[26] Liu, Jinshui, Shi Ma, and LingjieZang. "Preparation and characterization of ammonium-functionalized silica nanoparticle as a new adsorbent to remove methyl orange from aqueous solution." Applied Surface Science 265 (2013): 393-398.

[27] Saha, Bedabrata, et al. "Preferential and enhanced adsorption of different dyes on iron oxide nanoparticles: a comparative study." The Journal of Physical Chemistry C 115.16 (2011): 8024-8033.

[28] Mahmoodi, Niyaz Mohammad. "Synthesis of amine-functionalized magnetic ferrite nanoparticle and its dye removal ability." Journal of Environmental Engineering 139.11 (2013): 1382-1390.

[29] Ahmad, Rais, and Rajeev Kumar. "Adsorption studies of hazardous malachite green onto treated ginger waste." Journal of environmental management 91.4 (2010): 1032-1038.

[30] Saharan, Priya, et al. "Ultra fast and effective treatment of dyes from water with the synergistic effect of Ni doped ZnO nanoparticles and ultrasonication. "Ultrasonicssono chemistry 22 (2015): 317-325.

[31] Dalvand, Arash, et al. "Dye removal, energy consumption and operating cost of electrocoagulation of textile wastewater as a clean process." Clean–Soil, Air, Water 39.7 (2011): 665-672.

[32] Lin, Chia-Chang, and Wen-Tzong Liu. "Ozone oxidation in a rotating packed bed." Journal of Chemical Technology and Biotechnology 78.2-3 (2003): 138-141.

[33] Sharma, Sandeep Kumar, HaripadaBhunia, and Pramod Kumar Bajpai. "Photocatalyticdecolorization kinetics and mineralization of reactive black 5 aqueous solution by UV/TiO2 nanoparticles." CLEAN–Soil, Air, Water 40.11 (2012): 1290-1296.

[34] Mahmoodi, Niyaz Mohammad, JafarAbdi, and DariushBastani. "Direct dyes removal using modified magnetic ferrite nanoparticle." Journal of Environmental Health Science and Engineering 12.1 (2014): 1.

[35] Mahmoodi, Niyaz Mohammad, et al. "Decolorization and mineralization of textile dyes at solution bulk by heterogeneous nanophotocatalysis using immobilized nanoparticles of titanium dioxide." Colloids and Surfaces A: Physicochemical and Engineering Aspects 290.1 (2006): 125-131.

[36] Salehi, Raziyeh, et al. "Novel biocompatible composite (chitosan–zinc oxide nanoparticle): preparation, characterization and dye adsorption properties."Colloids and Surfaces B: Biointerfaces 80.1 (2010): 86-93.

[37] Ghaedi, Mehrorang, et al. "Comparison of silver and palladium nanoparticles loaded on activated carbon for efficient removal of Methylene blue: Kinetic and isotherm study of removal process." Powder Technology 228 (2012): 18-25.

[38] Kumar, K. Yogesh, et al. "Low-cost synthesis of metal oxide nanoparticles and their application in adsorption of commercial dye and heavy metal ion in aqueous solution." Powder technology 246 (2013): 125-136.

[39] Tan, KahAik, et al. "Removal of cationic dye by magnetic nanoparticle (Fe3O4) impregnated onto activated maize cob powder and kinetic study of dye waste adsorption." APCBEE Procedia 1 (2012): 83-89.

[40] Cao, Chunhua, et al. "In situ preparation of magnetic Fe 3 O 4/chitosan nanoparticles via a novel reduction–precipitation method and their application in adsorption of reactive azo dye." Powder Technology 260 (2014): 90-97.

[41] Basturk, Emine, and Mustafa Karatas. "Decolorization of antraquinone dye Reactive Blue 181 solution by UV/H 2 O 2 process." Journal of photochemistry and Photobiology A: Chemistry 299 (2015): 67-72.

[42] Ahmad, Rais, and Rajeev Kumar. "Adsorption of amaranth dye onto alumina reinforced polystyrene." CLEAN–Soil, Air, Water 39.1 (2011): 74-82.

[43] Fan, Lulu, et al. "Fabrication of magnetic chitosan nanoparticles grafted with β-cyclodextrin as effective adsorbents toward hydroquinol." Colloids and Surfaces B: Biointerfaces 95 (2012): 42-49.

[44] Mukhopadhyay, Arka, Anjan Kumar Dasgupta, and KrishanuChakrabarti. "Thermostability, pH stability and dye degrading activity of a bacterial laccase are enhanced in the presence of Cu 2 O nanoparticles." Bioresource technology 127 (2013): 25-36.

[45] Khataee, A. R., et al. "Biological treatment of a dye solution by MacroalgaeChara sp.: Effect of operational parameters, intermediates identification and artificial neural network modeling." Bioresource technology 101.7 (2010): 2252-2258.